CLAIMS

1. An apparatus for determining a dimension of a feature of a semiconductor device, comprising:

at least one source of electrons;

a focusing device positioned proximate to the source of electrons to focus electrons emitted by the source and form an electron beam, the focusing device focusing the electron beam to have first and second depths of focus and form at least one representation of the semiconductor device corresponding to electrons focused at the first and second depths of focus and impinging on the semiconductor device;

a support aligned with the electron beam and having a support surface to engage the semiconductor device and support the semiconductor device, one of the electron beam and the support being movable relative to the other of the electron beam and the support.

Sub B)

2. The apparatus of claim 1 wherein the support is movable relative to the source in a direction generally transverse to the electron beam.

3. The apparatus of claim 1 wherein the support is movable relative to the source in a direction generally aligned with an axis of the electron beam.

4. The apparatus of claim 1, further comprising a first detector spaced apart from the support to receive a first flow of electrons from the semiconductor device and generate a first signal corresponding thereto, and a second detector spaced apart from the support to receive a second flow of electrons from the semiconductor device and generate a second signal corresponding thereto.

5. The apparatus of claim 4, further comprising a third detector operatively coupled to one of the support and the source to detect movement of the one of the support and the source, the third detector generating a third signal corresponding to movement detected thereby.

Sub C2

6. The apparatus of claim 5, further comprising a memory device coupled to at least one of the detectors to store the signal generated by the detector.

7. The apparatus of claim 5, further comprising a display coupled to the detectors to graphically display a voltage generated by the first and second electron flows as a function of the movement detected by the third detector.

8. The apparatus of claim 5, further comprising a printing device coupled to the detectors to print a representation of a voltage generated by the first and second flows of electrons as a function of the movement detected by the third sensor.

9. The apparatus of claim 1 wherein the source of electrons is a first source, the electron beam corresponding thereto is a first electron beam focused at the first depth of focus, and the focusing device is a first focusing device, further comprising:

a second source of electrons spaced apart from the first source of electrons; and

a second focusing device positioned proximate to the second source of electrons to focus electrons emitted by the second source and form a second electron beam, the second focusing device focusing the second electron beam to have the second depth of focus simultaneously with the first focusing device focusing the first electron beam to have the first depth of focus.

10. The apparatus of claim 1 wherein the focusing device is a first focusing device and the electron beam is a first electron beam, further comprising:

a port surface positioned intermediate the source and the first focusing device and having first and second ports therethrough, the first port being positioned proximate to the source to form the first electron beam, the second port spaced apart from the first port to form a second electron beam; and

a second focusing device positioned proximate to the second port to focus the second electron beam to have the second depth of focus simultaneously with

the first focusing device focusing the first electron beam to have the first depth of focus.

11. The apparatus of claim 1 wherein the focusing device focuses the electron beam to have the first depth of focus prior to focusing the electron beam to have the second depth of focus.

12. An apparatus for determining a dimension of a feature of a semiconductor device, comprising:

a source of electrons;

a port surface having a first and second ports therethrough, the first port being positioned proximate to the source to form a first electron beam when electrons pass therethrough, the second port spaced apart from the first port to form a second electron beam when electrons pass therethrough;

a first focusing device positioned proximate to the first port and adjacent the first electron beam to focus the first electron beam on a first position;

Dul
B2

a second focusing device positioned proximate to the second port and adjacent the second electron beam to focus the second electron beam on a second position that is different from the first position; and

a support aligned with the first and second ports and having a support surface to engage the semiconductor device and support the semiconductor device at the first and second positions, one of the support and the source being movable relative to the other of the support and the source.

13. The apparatus of claim 12 wherein the support is movable relative to the source in a direction generally transverse to at least one of the first and second electron beams.

14. The apparatus of claim 12 wherein the support is movable relative to the source in a direction generally aligned with an axis of at least one of the first and second electron beams.

15. The apparatus of claim 12, further comprising a first detector spaced apart from the support to receive a first flow of electrons from the semiconductor device and generate a first signal corresponding thereto, and a second detector spaced apart from the support to receive a second flow of electrons from the semiconductor device and generate a second signal corresponding thereto.

16. The apparatus of claim 15, further comprising a third detector operatively coupled to one of the support and the source to detect movement of the one of the support and the source, the third detector generating a third signal corresponding to movement detected thereby.

17. The apparatus of claim 16, further comprising a memory device coupled to at least one of the detectors to store the signal generated by the detector.

18. The apparatus of claim 16, further comprising a display coupled to the detectors to graphically display a voltage generated by the first and second electron flows as a function of the movement detected by the third detector.

19. The apparatus of claim 16, further comprising a printing device coupled to the detectors to print a representation of a voltage generated by the first and second flows of electrons as a function of the movement detected by the third sensor.

20. An apparatus for determining a dimension of a semiconductor device feature, comprising:

first and second sources of electrons;

a first focusing device positioned proximate to the first source of electrons to focus a first electron beam emitted from the first source;

a second focusing device positioned proximate to the second source of electrons to focus a second electron beam emitted from the second source; and

a support aligned with the first and second focusing devices and configured to engage the semiconductor device, one of the support and the sources of

Sub B3 Cont

electrons being movable relative to the other of the support and the sources of electrons.

21. The apparatus of claim 20 wherein the support is movable relative to the sources of electrons in a direction generally transverse to at least one of the first and second electron beams.

22. The apparatus of claim 20 wherein the support is movable relative to the sources of electrons in a direction generally aligned with an axis of at least one of the first and second electron beams.

23. The apparatus of claim 20, further comprising a first detector spaced apart from the support to receive a first flow of electrons from the semiconductor device and generate a first signal corresponding thereto, and a second detector spaced apart from the support to receive a second flow of electrons reflected from the semiconductor device and generate a second signal corresponding thereto.

Sub C7

24. The apparatus of claim 23, further comprising a third detector operatively coupled to one of the support and the sources to detect movement of the one of the support and the sources, the third detector generating a third signal corresponding to movement detected thereby.

25. The apparatus of claim 24, further comprising a memory device coupled to at least one of the detectors to store the signal generated by the detector.

26. The apparatus of claim 24, further comprising a display coupled to the detectors to graphically display a strength of the first and second electron flows as a function of the movement detected by the third detector.

27. The apparatus of claim 24, further comprising a printing device coupled to the detectors to print a representation of a strength of the first and second flows of electrons as a function of the movement detected by the third detector.

28. A method for determining a dimension of a semiconductor device feature, comprising:

positioning a portion of the feature at a first axial distance from a focal point of an electron beam;

detecting a first flow of electrons corresponding to the electron beam and received from the feature when the electron beam impinges on the feature and the portion of the feature is spaced apart from the focal point by the first distance;

effectively moving at least one of the feature and the focal point of the electron beam to position the portion of the feature at a second axial distance from the focal point of the electron beam;

detecting a second flow of electrons corresponding to the electron beam and received from the feature when the electron beam impinges on the feature and the portion of the feature is spaced apart from the focal point by the second distance; and

analyzing the first and second flows to determine a dimension of the feature.

29. The method of claim 28 wherein the first flow of electrons is a portion of the electron beam reflected by the feature and the step of detecting the first flow includes detecting the reflected portion of the electron beam.

30. The method of claim 28 wherein the first flow of electrons is emitted by the feature when the electron beam impinges thereon, and the step of detecting the first flow includes detecting the emitted electrons.

31. The method of claim 28 wherein the step of moving at least one of the feature and the focal point comprises moving the feature relative to the focal point along an axis of the electron beam.

32. The method of claim 28 wherein the step of moving at least one of the feature and the focal point includes moving a source of the electron beam relative to the feature along an axis of the electron beam.

33. The method of claim 28 wherein the step of moving at least one of the feature and the focal point comprises focusing the electron beam to have the focal point spaced apart from the feature by the second distance.

34. The method of claim 28, further comprising moving one of the feature and the electron beam transverse to an axis of the electron beam.

35. The method of claim 28, further comprising translating one of the feature and the electron beam along a first path transverse to an axis of the electron beam when the portion of the feature is spaced apart from the focal point by the first distance and translating one of the feature and the electron beam along a second path transverse to the axis of the electron beam when the portion of the feature is spaced apart from the focal point by the second distance.

36. The method of claim 35 wherein the first path is generally the same as the second path.

37. The method of claim 35 wherein the step of analyzing includes forming a first representation of a voltage corresponding to the first flow of electrons as a function of a first transverse distance translated by the one of the focal point and the feature along the first path, the step further including forming a second representation of a voltage corresponding to the second flow of electrons as a function of a second transverse distance translated by the one of the focal point and the feature along the second path, the step still further including selecting one of the first and second representations.

38. The method of claim 37 wherein the step of selecting includes visually accessing the first and second representations.

39. The method of claim 37 wherein the step of selecting includes using a computer program to select the one of the first and second representations.

40. The method of claim 37 wherein the step of forming the first representation includes forming a graphical representation.

41. The method of claim 37 wherein the step of forming the first representation includes forming a tabular representation.

42. The method of claim 37 wherein the first representation has a first change in voltage corresponding to an edge of the feature and the second representation has a second change in voltage corresponding to the edge of the feature and the step of analyzing the first and second flows includes selecting the one of the first and second representations having a greater change in voltage per unit of transverse distance.

43. The method of claim 42, further comprising scanning a remaining portion of the semiconductor device with the semiconductor device positioned at the one of the first and second axial distances that corresponds to the selected one of the first and second representations.

44. The method of claim 37, further comprising:

storing data corresponding to an intensity of the first flow of electrons as a function of a first transverse distance translated by the one of the focal point and the feature along the first path; and

storing data corresponding to an intensity of the second flow of electrons as a function of a second transverse distance translated by the one of the focal point and the feature along the second path.

45. The method of claim 35 wherein the step of analyzing includes forming a first representation of a voltage corresponding to the first flow of electrons as a function of a first transverse distance translated by the one of the focal point and the feature along the first path, the step further including forming a second representation of a voltage corresponding to the second flow of electrons as a function

of a second transverse distance translated by the one of the focal point and the feature along the second path; the step still further including combining the first and second representations.

46. The method of claim 28 wherein the step of analyzing the first and second flows includes determining a lateral dimension of the feature.

47. The method of claim 28 wherein the step of analyzing the first and second flows includes determining a vertical dimension of the feature.

48. The method of claim 47 wherein the step of moving at least one of the feature and the focal point includes

measuring a first position of the focal point when the feature is spaced apart from the focal point by the first distance,

focusing the electron beam to have the focal point spaced apart from the feature by the second distance, and

measuring a second position of the focal point when the feature is spaced apart from the focal point by the second distance.

49. A method for measuring a dimension of a semiconductor device feature, comprising:

moving one of a first electron beam and the feature transversely relative to the other of the first electron beam and the feature, the first electron beam impinging on the feature and having a first depth of focus centered at a first point;

receiving a first flow of electrons from the feature corresponding to the first electron beam;

moving one of a second electron beam and the feature transversely relative to the other of the second electron beam and the feature, the second electron beam impinging on the feature and having a second depth of focus centered at a second point, the second depth of focus being different from the first depth of focus;

receiving a second flow of electrons from the feature corresponding to the second electron beam; and

analyzing the first and second flows to determine a dimension of the feature.

50. The method of claim 49 wherein the first flow of electrons is a portion of the first electron beam reflected by the feature and the step of receiving the first flow includes receiving the reflected portion of the first electron beam.

51. The method of claim 49 wherein the first flow of electrons is emitted by the feature when the first electron beam impinges thereon, and the step of receiving the first flow includes receiving the emitted electrons.

52. The method of claim 49 wherein the step of analyzing includes forming a first representation of an intensity of the first flow of electrons as a function of a first transverse distance moved by the one of the first electron beam and the feature, the step further including forming a second representation of an intensity of the second flow of electrons as a function of a second transverse distance moved by the one of the second electron beam and the feature, the step still further including selecting one of the first and second representations.

53. The method of claim 52 wherein the step of forming a first representation of an intensity of the first flow of electrons includes forming a representation of a voltage corresponding to the first flow of the electrons.

54. The method of claim 52 wherein the first representation has a first change in intensity corresponding to an edge of the feature and the second representation has a second change in intensity corresponding to the edge of the feature and the step of analyzing the first and second flows includes selecting the one of the first and second representations having a greater change in intensity per unit of transverse distance moved.

55. The method of claim 49 wherein the step of analyzing includes forming a first representation of an intensity of the first flow of electrons as a function of a first transverse distance moved by the one of the first electron beam and the feature, the step further including forming a second representation of an intensity of the second flow of electrons as a function of a second transverse distance moved by the one of the second electron beam and the feature, the step still further including combining the first and second representations to form a composite representation.

56. The method of claim 49 wherein the step of moving one of the first electron beam and the feature is simultaneous with the act of moving one of the second electron beam and the feature.

57. The method of claim 49 wherein the step of moving one of the first electron beam and the feature occurs before the act of moving one of the second electron beam and the feature.

58. The method of claim 49, further comprising emitting the first and second electron beams sequentially from a single port.

59. The method of claim 49, further comprising emitting the first electron beam from a first port and simultaneously emitting the second electron beam from a second port.

60. The method of claim 49, further comprising emitting the first and second electron beams from a single electron gun.

61. The method of claim 49, further comprising emitting the first electron beam from a first electron gun and emitting the second electron beam from a second electron gun.

62. The method of claim 49, further comprising:

storing data corresponding to an intensity of the first flow of electrons as a function of a first transverse distance moved by the one of the first electron beam and the feature; and

storing data corresponding to an intensity of the second flow of electrons as a function of a second transverse distance moved by the one of the second electron beam and the feature.

63. The method of claim 49 wherein the step of analyzing the first and second flows includes determining a lateral dimension of the feature.

64. The method of claim 49 wherein the step of analyzing the first and second flows includes determining a vertical dimension of the feature.

65. The method of claim 64 wherein the step of determining the vertical dimension includes determining a distance between the first and second points, the first electron beam having the first depth of focus centered at the first point, the second electron beam having the second depth of focus centered at the second point.

66. A method for determining a width of a feature of a semiconductor device having a first surface and a second surface opposite the first surface, the feature having two first edges spaced apart from one of the first and second surfaces by a first distance and two second edges spaced apart from one of the first and second surfaces by a second distance, the method comprising:

focusing a first electron beam to have a first depth of focus approximately centered at the first distance and receiving a first flow of electrons from the feature corresponding to the first electron beam;

focusing a second electron beam to have a second depth of focus centered at a third distance different than the first and second distances and receiving a

second flow of electrons from the feature corresponding to the second electron beam; and

measuring a distance between the first edges of the feature by moving one of the feature and the first electron beam relative to the other of the feature and the first electron beam transverse to an axis of the first electron beam along a transverse path while the first electron beam has a depth of focus approximately centered at the first distance.

67. The method of claim 66, further comprising emitting the first and second electron beams sequentially from a single source.

68. The method of claim 66, further comprising emitting the first electron beam from a first port and simultaneously emitting the second electron beam from a second port.

69. The method of ~~claim 66~~ wherein the step of focusing the first electron beam is simultaneous with the step of focusing the second electron beam.

70. The method of claim 66 wherein the step of focusing the first electron beam occurs after the step of focusing the second electron beam.

71. The method of claim 66 wherein the step of measuring the distance between the first edges includes detecting an intensity of the first flow of electrons as a function of a transverse distance moved by the one of the first electron beam and the feature and determining a distance between changes in the intensity of the first flow.

72. The method of claim 66, further comprising storing data corresponding to the intensity of the first flow of electrons as a function of a transverse distance moved by the one of the first electron beam and the feature.

73. A method for determining a width of a feature of a semiconductor device having a first surface and a second surface opposite the first surface, the feature having first edges spaced apart from one of the first and second surfaces by a first distance and second edges spaced apart from one of the first and second surfaces by a second distance, the method comprising:

focusing a first electron beam to have a first depth of focus approximately centered at the first distance and receiving a first electron flow from the feature corresponding to the first electron beam;

focusing a second electron beam to have a second depth of focus approximately centered at the second distance and receiving a second electron flow from the feature corresponding to the second electron beam, the second distance being different from the first distance;

measuring the first electron flow to form a first measurement;

measuring the second electron flow to form a second measurement;

combining the first and second measurements to form a composite measurement; and

analyzing the composite measurement to determine a width of the feature.

74. The method of claim 73, further comprising moving one of the feature and the first electron beam relative to the other transverse to an axis of the first electron beam along a first transverse path and moving one of the feature and the second electron beam relative to the other transverse to an axis of the second electron beam along a second transverse path.

75. The method of claim 74 wherein the composite measurement includes a voltage generated by the first electron flow as a function of a distance moved by the one of the first electron beam and the feature along the first transverse path, the composite measurement further including a voltage generated by the second electron flow as a function of a distance moved by the one of the second electron beam and the feature along the second transverse path, and the step of analyzing the

composite measurement includes measuring a distance between changes in the voltage generated by one of the electron flows that correspond to the first edges.

76. The method of claim 75 wherein the step of analyzing the composite measurement includes measuring a first distance between changes in the voltage generated by the first electron flow that correspond to the first edges and measuring a second distance between changes in the voltage generated by the second electron that correspond to the second edges.

77. The method of claim 73 wherein the step of focusing the first electron beam is simultaneous with the step of focusing the second electron beam.

78. The method of claim 73 wherein the step of focusing the first electron beam occurs after the step of focusing the second electron beam.

79. The method of claim 73, further comprising emitting the first and second electron beams sequentially from a single port.

80. The method of claim 73, further comprising emitting the first electron beam from a first port and simultaneously emitting the second electron beam from a second port.

81. The method of claim 73 wherein the first electron flow is a portion of the first electron beam reflected by the feature and the step of measuring the first electron flow includes measuring the reflected portion of the first electron beam.

82. The method of claim 73 wherein the first electron flow is emitted by the feature when the first electron beam impinges thereon, and the step of measuring the first flow includes measuring the flow of emitted electrons.